DOCUMENT RESUME

ED 247 524 CS 007 626

AUTHOR Bulcock, Jeffrey W.; Beebe, Mona J.
TITLE Interpretive and Formal Models of Discourse Processing.
SPONS AGENCY Memorial Univ., St. John's (Newfoundland). Faculty of Education.; Social Sciences and Humanities Research Council of Canada, Ottawa (Ontario).
PUB DATE Mar 84
NOTE 46p.
PUB TYPE Viewpoints (120)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Cognitive Processes; *Discourse Analysis; *Language Processing; *Models; Reading Processes; *Reading Research; *Research Methodology; Theories
IDENTIFIERS *Qualitative Research; *Quantitative Research

ABSTRACT

Distinguishing between interpretive and formal models of discourse processing and between qualitative and quantitative research, this paper argues that formal models are the analogues of interpretive models, and that the two are complementary. It observes that interpretive models of reading are being increasingly derived from qualitative research while formal models are equated with quantitative research, and thus the interpretive/formal modelling distinction tends to parallel the qualitative/quantitative research distinction. The paper then illustrates this view using the interpretive model and formal model versions of the discourse processing theory of reading. (Author/HTH)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED247524

INTERPRETIVE AND FORMAL MODELS OF DISCOURSE PROCESSING

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
☐ This document has been reproduced as received from the person or organization originating it.
X Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy

Jeffrey W. Bulcock*

Memorial University of Newfoundland

Mona J. Beebe

MacDonald Drive Elementary School

St. John's, Newfoundland

March 1984

The research reported in this paper was supported by research grants awarded the first author by the Social Sciences and Humanities Research Council of Canada and the Faculty of Education, Memorial University of Newfoundland.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
J.W. Bulcock
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CS 007 626

TABLE OF CONTENTS

	Page
ABSTRACT	i
LIST OF TABLES	ii
Interpretive and Formal Models of Discourse Processing	1
From Quantitative to Qualitative Methods	3
Interdependence of Quantitative and Qualitative Approaches	6
The Interpretive Model	9
The Formal Model	15
Discussion and Conclusion	24
REFERENCES	30

ABSTRACT

Interpretive and Formal Models of Discourse Processing

Distinctions are made between interpretive and formal models, and between qualitative and quantitative research. It is argued that formal models are the analogues of interpretive models and that the two are complementary. Interpretive models of reading are being increasingly derived from qualitative research while formal models are equated with quantitative research; thus, the interpretive/formal modelling distinction tends to parallel the qualitative/quantitative research distinction. These views are illustrated by reference to the interpretive model and formal model versions of the discourse processing theory of reading.

LIST OF TABLES

Table

1 Correlations, Levels of Statistical Significance, Means and Standard Deviations in the Recall Strategies Model of Reading

2 Ordinary Least Squares Regression Results

3 Comparisons Between an Ordinary Least Squares Estimate and Four Ridge Regression Estimates of the Parameters of the Recall Strategies Model of Reading

Interpretive and Formal Models of Discourse Processing

Quantitative research is different in its orientation than qualitative research, but the two approaches are complementary. They are opposite sides of the same coin. In the field of reading interpretive models of reading are increasingly being derived from studies in the qualitative tradition. Qualitative researchers have found that social phenomena require interpretation in terms of the manner in which they are perceived. Thus, their explanations are formulated both in terms of the intentions of their research subjects and in terms of the reasons given for behaving in the manner observed.

The propositions (postulates) of interpretive models, then, tend to be specified largely in terms of the phenomena (concepts) observed; which may be readily expressed in the common language. Historically, however, ambitious researchers have seldom been satisfied with this state of affairs. There are so many potential observables; hence, so many propositions, that the important scientific task of constructing simple, but powerful, explanations becomes unmanageable. Nevertheless, explanation in terms of observables is usually easily tested; and, further, its applicability to practical problems is usually straightforward and direct; hence, more inclusive (Willer and Webster, 1970).

On the one hand, interpretive models formulated in common language terms are easily tested, practical and inclusive; on the other hand they lack generalizability. Explanation in terms of observables tends to be situation specific, whereas scientific explanation is intended to be applicable not merely to a single situation but to all situations which fall within the scope of the explanation. Qualitative modelling, then, tends to consist of efforts to capture in microcosm, most, if not all, the features of a model's macro counterpart. Such all purpose modelling, however, is seldom successful. The important question is not whether the model is adequate for all purposes; but, rather, whether its structural components are relevant and necessary for the purposes for which the model was constructed.

The purpose of modelling is not to capture reality, nor to mirror it; rather, it is to reduce the features of that reality to a manageable form to facilitate explanation and/or prediction. Generalizability usually calls for model formalization; which, in turn, calls for mathematization and quantification (Kaplan, 1964:275). In other words, interpretive models -- often formulated on the basis of qualitative research -- are but concrete instances of more abstract formal models.

The most important assumption in this paper, therefore, is that interpretive models can have formal analogues and that the two are complementary. The purpose of the paper is to give substance

to this claim by distinguishing between interpretive and formal models of discourse processing. A second purpose of the paper is to draw the reader's attention to recent research by Drum and Lantaff in which they have described a new, flexible method for classifying and scoring the recall responses of readers.

From Quantitative to Qualitative Methods

RRQ readers are well informed about the differences between quantitative and qualitative research, or what Bellack (1978) refers to as "mainstream empiricism" and "interpretive" research respectively. Methodological empiricism reigned virtually unchallenged for the first five years of the RRQ's existence. In their dedication editorial Clymer and Summers (1965:3) expressed the editorial policy of the journal in the following way: "We will report experimental, statistical and technical articles as well as integrative, critical and comprehensive reviews of the literature". The strict adherence to this policy would preclude research which today is labelled ethnomethodology, the case study, participant observation and phenomenology. These alternative approaches to methodological empiricism have one common interest; namely identification of a subject's personal interpretation or subjective meaning of an event as the basis for understanding social behavior.

What do miscues tell us about the strategies children use for decoding graphic display? To what extent does the analysis of a reader's unaided recall provide insight into how meaning is gained from print? Both are scientific questions. In the case of the first question, the researcher is concerned with the interpretation of the reading miscues of a reader, while the second question is getting at why readers recall some idea units in a text in preference to others. In the extant research literature few researchers addressing these questions have conducted controlled experiments; neither have they emphasized the causal relationships between the concepts of their models. For the most part they have not drawn on the methodology of the natural sciences for inspiration, and have not been prepared to quantify their models at the cost of attenuating the significance and integrity of their inquiries.

The early RRQ editorial policy would have excluded much of the research over the past fifteen years which has addressed these two questions -- research which has been in the psycholinguistic and cognitive science traditions respectively. But within five years Farr and Weintraub (1969/70:3), the new editors, had made an appeal for methodological articles. A few years later the same editors (1975/76) were soliciting articles employing "unique approaches" and articles designed to show how methodologies from other disciplines could be applied to reading

research. The same year Wolf and Tymitz (1976/77) in a guest editorial, drew attention to the characteristics and advantages of qualitative research in the ethnomethodological tradition.

Other RRQ editorials (Fairweather and Farstrap, 1977/78:3; and Weintraub and Farr 1977/78:172) continued to question the dominance of mainstream empiricism and advocated the use of alternative methodologies including ethnographic and case study research. By the end of the 1970s qualitative approaches had taken hold. Thus, the present RRQ editors (Pearson and Samuels, 1980:181-182) were able to write that:

> ... new methodologies have arisen to allow us to investigate the complexities of the structure of text and the structure of knowledge in human memory ... The psycholinguistic tradition of the Sixties allowed us to deal adequately with one microstructure of text (e.g., relations within sentences). The work of cognitive psychologists in the Seventies has resulted in tools to examine the macrostructure of text: intersentential relations, semantic networks, scripts, schemata, story grammars, and so on.

The current editors, in fact, went so far as to say that the new approaches constituted a paradigm shift.

Interdependence of Quantitative and Qualitative Approaches

It would be fair to conclude from the above discussion that reading researchers have broken the monopoly of methodological empiricism. Fewer than half the RRQ articles today are "experimental, statistical and technical" in Clymer and Summers' sense.

Ironically, however, qualitative research resulting in interpretive modelling may have placed novel and exacting demands on the quantitative researcher. As Kaplan (1964:72) points out, "in the history of science qualitative and quantitative considerations have worked hand in hand". According to Kaplan (1964:267) a model may be informally expressed in the form of a set of conceptual analogues; in which case it may be referred to as an interpretive or semantical model. On the other hand, a model may be expressed more formally either by a set of equations or by mathematical formulae. Both the informal interpretive model and the formal mathematical model are theories. The one may be expressed as a logical set of propositions or verbal postulates while the other consists of a mathematical description of the same state of affairs. One is a conceptual, semantic, linguistic model, the other is a nonverbal, mathematical, linguistic model -- linguistic in that each has carefully specified semantic and syntactic structure irrespective of the symbols used.

Even if the concepts of an interpretive model and their specified relationships are not quantified the model is still a theory because quantification is not a necessary condition of scientific inquiry. The scientist, however, has not finished when he has formulated an interpretive model. The model has to be shown to be consistent. Thus, the researcher has to demonstrate that the postulated relationships have "the markings of enduring or recurrent constituents in the flow of experience" because science involves a search for systematic knowledge and for generalizability "in which the particularity of the goings-on is subsumed under a universalized 'what' ..." (Kaplan, 1964:85).

On the one hand, there is an informal interpretive model which is increasingly being derived on the basis of qualitative inquiry; on the other hand there is the formal mathematical expression of that model. Qualitative studies as often as not are conducted using small, non-representative samples. They are able to provide the fundamentally important observational details on which scientific explanations may be originally based. The propositions and postulates of an interpretive model can be derived from such inquiries. In contrast, the quantitative study -- including those of the survey variety -- can be conducted on larger, more representative samples of the target population. By intent and design the quantitative study is more likely to be generalizable and expressible in the form of systems of

mathematical equations. The additional advantage of the research conducted on representative samples is that the policy recommendations which flow from such studies are likely to be less tentative than those based on smaller scale, qualitative research findings.

These currently controversial ideas can best be presented through example. Consider the research on text organization and discourse processing by Drum (1978) and Drum and Lantaff (1977). In the next two sections of the paper the Drum and Lantaff study is formulated first as an interpretive model, then as a formal model. In the interpretive model section the postulates (hypotheses) derived from Drum and Lantaff's qualitative research are formulated. In the formal model section the specified interpretive model relationships are estimated such that the relative magnitudes of the model parameters are made transparent.

The important point to bear in mind is that from the outset the interpretive model in the Drum and Lantaff research was not overly constrained by a preconceived research design in the quantitative tradition. Thus, the ex-post-facto formalization of their model involves fitting a mathematical model to the interpretive model -- not the other way around. Fitting a formal model last instead of specifying it in advance is a departure from the more conventional approach to modelling. But, because the researcher is not constrained to fit his inquiry within the

boundaries of a preconceived form, he has an added degree of flexibility. This flexibility, however, is not without its costs. The ex-post-facto fitting of formal models may give rise to unanticipated and, sometimes, formidable mathematical specification problems as we shall see.

The Interpretive Model

Text analysis over the past decade has demonstrated that reading is responsive to the number and complexity of idea units or propositions in a text, and that the capacity of children to recall information is responsive to the relative importance of the idea units. There are two sides to the theory of discourse processing. The first is concerned with the question, "How does a reader integrate the semantic structure of a text into his existing knowledge base?" and the second with the question, "How is a reader's existing knowledge organized so that it is possible to accomplish this task?". An answer to the first question calls for a theory of discourse processing while the answer to the second question calls for a theory of reader-text interaction.

Frame theory (Minsky, 1974), schema theory (Kintsch, 1974; Mandler, 1974) and variants such as script theory (Shank and Abelson, 1977) have been used to account for reader-text interaction. Here, we are concerned with the first of the above questions: the theory of discourse processing. Research on

discourse processing has focussed on five topics:

(i) the responsiveness of reading time to the impact of the number and complexity of the propositions in a text (Kintsch, 1974; Kintsch and Vipond, 1979);

(ii) the responsiveness of text recall to the manner in which the ideas are organized and the importance of the ideas (Meyer, 1975, 1977);

(iii) the consistency of text recall as a function of the discourse processes used by readers to construct text summaries (Kintsch and van Dijk, 1978; van Dijk, 1977);

(iv) the responsiveness of text recall to the making of inferences based on either information implied in the text or information contained in the reader's knowledge base (Fredericksen, 1977, 1979); and

(v) the responsiveness of text recall to children's reading competence (Drum, 1978; Tierney et al, 1978/79).

Nearly all these studies have used text recall as a dependent variable, and obviously so because the integration of the semantic structure of a text into the reader's knowledge base is not possible until the text has been read. By the same token, a passage cannot be recalled until text integration has occurred. The type of recall is an outcome of the reading process. On the other hand, one purpose of recall analysis is to gain insight into the manner in which a reader obtains meaning from print; that is, to find out how and why the reader selects the semantic units to be assimilated into his pre-existing knowledge structure for later retrieval.

Though the research leading to the formulation of a model of discourse processing has been exclusively based on the linking of a reader's text recall to the author's text organization, recall analysis may also be used as an independent procedure for gauging the discourse or recall strategies of a reader. In this way, instead of finding out whether reading recalls are responsive to the different reading abilities of children as Tierney et al (1978/79) or Drum (1978) did, it becomes possible to address the equally interesting question: "To what extent is a reader's reading comprehension responsive to his recall strategies?" or, in practical terms, "Which recall strategies are the most effective determinants of reading competence?".

In order to answer these questions it is necessary for the text recall activity per se to be divorced from the particular passage used as the catalytic agent. The passage read may be regarded, then, as the vehicle or agent for determining the extent to which the fit between the author's meaning and the reader's meaning depends on the interaction of text information with the reader's prior knowledge. Once this has been ascertained the responsiveness of reading comprehension (as independently measured) to the strategies that readers use for gaining meaning (also independently measured) may be gauged.

"What are these recall strategies or discourse processing abilities?" and "How does one go about analyzing text in order to identify the different text recall abilities of the reader?" There are several approaches to discourse processing designed to identify the different recall responses of readers. The construction of propositional hierarchies developed by Kintsch (Kintsch and Keenan, 1973; Kintsch, 1975, 1977; Kintsch and van Dijk, 1978) may have been the earliest approach. The story schema and story grammar approaches (Norman and Rumelhart, 1975; Mandler, 1977; Mander and Johnson, 1977; Meyer, 1975; Stein, 1978; Stein and Glen, 1979; and Thorndyke, 1977), like the propositional approach, are expressed as the structures of specific texts, types of prose or stories.

Here, however, we focus on a lesser known but extremely flexible approach developed by Drum and Lantaff (1977) and modified by Drum (1978). Following Kintsch propositional units are identified for use as templates in scoring subject protocols. Each unit is classified into one of four categories: namely: (i) text specific responses, (ii) text entailed responses, (iii) text evoked responses, and (iv) text external responses. These have been slightly modified by Fagan (Beebe et al, 1984) and include the following categories: (i) text specific information which includes verbatim information, or in paraphrase form, information from a single utterance of the original; (ii) text entailed information in which the information retrieved is a paraphrase from more than one unit of text, a summary or a correct inference; (iii) text erroneous information which involves using text information which the reader had confused or combined in an erroneous way; and (iv) text external information which includes vague generalizations or story telling conventions.

These categories represent the amount of text as compared to the amount of background knowledge that the reader used. Text specific responses, for example, are largely text bound since they involve identical phrasing from the text or a lexical paraphrase. In this sense they represent what Tierney et al. (1978:554) refer to as abstractive discourse processing which is

necessary but not sufficient for complete meaning. Text entailed responses involve the interaction of text and a reader's prior knowledge, and in this sense they reflect constructive processing (Bartlett, 1932). Text erroneous responses involve either incorrect processing of text or inappropriate use of background knowledge. Text external responses are different from the others in that they have little to do with knowledge of text per se. They are storytelling conventions at best, but often merely represent vague generalizations.

One may infer from the recall categories what processes are involved in obtaining meaning. Recalls in the text specific category result from memory reproduction and transformation processes which provide for lexical substitution. Text entailed information is produced through a reconstruction process or by transformation involving explication of text relationships. The erroneous category would seem to indicate that some of these processes have broken down during recall. Finally, text external responses are probably only minimally related to text since they seem to consist of conventions for dealing with information that has not been adequately stored or which cannot be retrieved.

The emergent interpretive model of discourse processing gives rise to the following postulates:

(i) that text specific and text entailed recalls will be positively related to reading comprehension; but

(ii) because text entailed recalls reflect both abstractive and reconstructive processes they are likely to be more closely related to reading comprehension than text specific recalls;

(iii) that text erroneous recalls will be negatively related to reading comprehension; and

(iv) text external recalls will have little relationship to reading.

The Formal Model

The relationship specified by the above postulates may be captured by a simple regression equation of the form:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e \qquad (1)$$

where Y = reading comprehension, X_1 = text specific recall information, X_2 = text entailed recall information, X_3 = text erroneous recall information, X_4 = text external recall information, a = the constant term or intercept for the four dimensional equation, b_1, b_2, b_3 and b_4 = regression weights or beta coefficients, and e = the random error term or residual.

Ninety-four grade four pupils (47 boys and 47 girls) -- all of whom were reading at the grade four level or higher -- were selected from four classrooms in two schools in order to estimate the formal model. All read the same 741 word passage which was about the length of the average story found in the grade four basal reader. Scores for each child on each independent variable (X_1 through X_4) were based on their unaided recalls of the passage. The reading comprehension measure (the Y variable) was a grade equivalent score from the Canadian Tests of Basic Skills (King and Hieronymus, 1974). The matrix of correlations between the variables, their level of statistical significance, their means and standard deviations are presented in Table 1.

Insert Table 1 about here

As hypothesized, text specific and text entailed recalls were positively related to reading while the amount of erroneous information given was negatively related to reading. See Table 1. Furthermore, the relationship between text external information and reading -- as hypothesized -- was not significant. From the ordinary least squares (OLS) regression results in Table 2 one notes that when text entailed and text erroneous information are simultaneously taken into account, the impact of text specific information on reading is severely

attenuated. Because the regression effects of text specific and text external information are negligible it seems that most of the variance in reading comprehension is a function of two factors -- text entailed and text erroneous recall strategies respectively.

Insert Table 2 about here

On the surface it seems that the results presented in Tables 1 and 2 provide impressive support for all four postulates; hence support for the theory of discourse processing. There are, however, two disconcerting and unanticipated findings. In Table 1 it is shown that the text erroneous recall information (X_3) correlates positively and significantly with both the text specific and text entailed variables (X_1 and X_2). In other words, the more text specific and text entailed recalls are given the greater the amount of accompanying erroneous recall information. It would seem that the greater the amount of both abstractive (text specific recalls) and constructive (text entailed recalls) information provided the greater the probability that some erroneous information will also be provided.

The second unanticipated finding is of greater interest and requires explanation. In Table 2 the standardized betas for both the text entailed (X_2) and text erroneous (X_3) parameters are

larger than the simple correlation values for the same relationships. This finding suggests that the OLS estimates are inflated; hence, untrustworthy. The model could well be functionally or mathematically misspecified.

Beta coefficients larger than the underlying correlation coefficients are uncommon, but consistent with two possibilities. The first is that the apparently inflated estimates are attributable to the problem of multicollinearity. The second possibility is that suppressor effects are operating. The first condition is commonplace in the social sciences. The second is an example of a type of confounding effect. Confounding variables are also ubiquitous in social science research (Kish, 1975), but confounding in the guise of a suppression effect is rare. Logically, it is preferred to examine the data in order to discern the presence or absence of multicollinearity before looking for supression effects.

Multicollinearity denotes the existence of substantial correlations among the independent variables of a model. Its effect is to invalidate some of the basic assumptions underlying the mathematical estimation of simultaneous equations. For example, it produces large standard errors so that the estimates of the true model parameters become unstable. The parameter estimates will fluctuate from sample to sample, and often drastic changes in the estimates will occur after only minor data

revision. All too often, then, conflicting conclusions will be reached from the usual tests of significance. There are numerous studies which verify these statements (for example, Blalock, 1963, 1964; Christ, 1966; Farrar and Glauber, 1967).

Recently, a technique known as ridge regression (RR) has been used to cope with the multicollinearity problem. RR involves the introduction of a modest amount of bias into an equation in an effort to reduce the harmful effects of the variance inflation which usually accompanies attempts to analyze nonorthogonal data. Vinod (1978) in a review paper, notes that Monte Carlo simulation experiments have demonstrated the superior properties of RR for coping with collinearity-prone data compared to OLS regression. Unfortunately, RR is not a single technique but rather a family of methods, each of which will generate different parameter estimates, and no single method is guaranteed to give the best set of estimates under all conditions. In Table 3 four different RR methods are used to estimate the parameters of the recall strategies model of reading. The results of each method may be compared to those of other RR methods and to those of the OLS analysis.

Insert Table 3 about here

The RR estimates in Table 3 differ very little from one another but they differ appreciably from the least squares estimates. The 'k' in Table 3 refers to the biasing parameter introduced by each RR method. Note that in each case the bias introduced is less than 0.15; that is, very small. Dmax refers to the degree of multicollinearity; where, on a scale from 0 to 1, Dmax = 0 represents no collinearity, while Dmax = 1 represents perfect collinearity. A Dmax of 0.50 indicates that the variance inflation of the estimated betas is over twice as high as what it would be if the data set were orthogonal. Though a Dmax of 0.50 may be technically undesirable it should not be regarded as excessive; and a Dmax of 0.57 which was reported for the OLS equation should not be considered as excessive either. Note that each RR procedure reduces the Dmax ratio closer to zero, thus, the modestly inflated OLS coefficients are reduced in magnitude accordingly, as is the R-square goodness of fit value. For further information on the theory and practice of ridge regression as a technique for coping with the collireary problem in social science research see Bulcock et al. (1981) and Bulcock and Lee (1983).

Since the standardized OLS coefficient for the relationship between text entailed information (X_2) and reading comprehension (Y) is significantly higher than that reported in the RR equations one may conclude that it is probably inflated. Thus,

the finding that this coefficient is larger than the underlying correlation coefficient is probably spurious. The same conclusion, however, cannot be drawn with regard to the text erroneous (X_3) and reading comprehension (Y) relationship. Whereas the standardized betas for the text entailed-reading relationship (p_{YX2}) in all the RR equations were lower than simple correlation coefficient ($r_{YX2} = .391$), in the case of the text erroneous-reading relationship the parameter estimate (p_{YX3}) for each RR equation was higher than the parallel simple correlation coefficient ($r_{YX3} = -.226$). The RR analysis did attenuate the P_{YX3} relationship compared to the OLS analysis but not below the level of the zero-order coefficient (r_{YX3}).

It may be concluded, therefore, that the text specific (X_1) and test entailed (X_2) variables were operating as suppressor variables. In other words, these variables were operating to suppress the true effect of the text erroneous factor on reading. This conclusion requires elaboration.

A suppressor variable is one which when controlled strengthens a previously suppressed association between an independent variable of interest and the dependent variable. In the present case text erroneous recall information (X_3) is the variable of interest and there are two suppressor variables; the text specific and text entailed variables. The suppression occurs because when the text specific and text entailed variables

are not statistically controlled they dilute or attenuate the association between the text erroneous variable and reading. The suppressors, which are positively related to the text erroneous variable are not relevant to the relationship of interest; but, nevertheless, they manage to reduce the true relationship. In effect they operate in such a way as to permit only a fraction of the variability in text erroneous recalls to affect reading.

Consider the present instance where the correlation between the text erroneous variable and reading is -.226. When, through the application of the regression procedure, statistical controls are placed on the text specific and text entailed suppressor variables, a much stronger relationship between the text erroneous variable and reading is revealed or allowed to emerge. What seems to have happened is that the suppressed portion of the text erroneous variable which is related to reading alone has been allowed to contribute its "true" effect to the criterion, reading. Controlling the suppressor variables, then, has resulted in the refinement of the text erroneous information component of the model; and as a result its association with reading has been strengthened. From a zero-order relationship of -.226 the magnitude of the relationship has increased to -.317 in the case two RR estimates.

The four RR analyses generated different estimates but by and large they differed only at the third decimal place. In other

words any one set of RR estimates confirmed the authenticity of the other three. On the other hand the RR analyses differed appreciably from the OLS results and for this reason two conclusions were drawn. In the first place the beta estimate of .437 for text entailed-reading parameter, other things equal, was found to be artifactually high due to the presence of multicollinearity. In the second place, though the beta estimate of 0.372 for the text erroneous-reading relationship also seemed to be spuriously high due to multicollinearity, in fact, when the collinearity problem was handled using the biased, variance reduction RR approach this was found not to be the case. The apparently inflated estimate was not due to collinearity; rather, to what is known as a suppression effect. The variables text specific recalls and text entailed recalls operated as suppressor variables; hence masked the true relationship between text erroneous recall and reading comprehension. In sum, the multicollinearity problem was not too problematic; therefore, erroneous conclusions would probably not have been drawn from the OLS estimates. Nevertheless, the researcher will have greater confidence in his model as a result of the fact that both OLS and RR results support the recall strategy theory of reading.

Discussion and Conclusion

The results demonstrated the predictive validity of the discourse processing or recall strategies model of reading. There were two strategies of the four examined which proved to be significant and powerful predictors of the reading comprehension scores on a standardized test. The more text entailed information in a child's recall, the higher the comprehension score; the more text erroneous information in the recall the lower the score. The text specific strategy was not important in and of itself when the effects of text entailed and text erroneous information were taken into account; rather, its importance stemmed from its relationship to reading via text entailed information. That is, text specific information influences comprehension because this is what is abstracted from a passage, integrated into the reader's cognitive structure, and as such becomes part of what is reconstructed and retold as largely text entailed information.

If this interpretation of the findings is accurate a more correct model specification to that of equation (1) may be of the form:

$$X_2 = a_1 + b_1X_1 + e_1 \qquad (2)$$

$$X_3 = a_2 + b_1X_1 + e_2 \qquad (3)$$

$$Y = a_3 + b_2X_2 + b_3X_3 + e_3 \qquad (4)$$

where the structural elements X_1, X_2, X_3 and Y are the same as defined earlier.

There is a possibility that the magnitude of the relationship between text entailed information and reading depends upon effective test specific recall processing. What is postulated here is that the effectiveness of the text entailed strategy of discourse will depend on the amount of text specific processing that can be conducted — a possibility that seems reasonable. This possibility may be examined through the formulation of an equation of the form:

$$Y = a_1 + b_1X_1 + b_2X_2 + b_3X_3 + b_4Z_1 + e_1 \qquad (5)$$

where $Z_1 = X_1 * X_2$.

The possibility also arises that if $b_4 \neq 0$; that is, if the hypothesis embedded in equation (5) is supported, then the relationship between text entailed processing and reading may be more exponential in form than linear. This hypothesis may be examined by estimating an extended model containing the following polynomial term:

$$Y = a_1 + b_1X_1 + b_2X_2 + b_3X_3 + b_4Z_1 + b_5Z_1^2 + e_1 \qquad (6)$$

The search for the correct functional form of the discourse processing model as illustrated by equations (5) and (6) is not conducted here. The point is made, however, that model formalization has a heuristic aspect. Model formalization can also promote theory integration as noted by Beebe (1984) who has taken a formal model of the cueing strategy theory of reading (equation 7) and integrated it with the formal model of discourse processing (equation 1). Since the decoding of information logically precedes its encoding it is hypothesized that discourse processing is responsive to the cueing strategies that readers use, and that reading is responsive to both sets of strategies.

The cueing strategy model may be expressed as follows:

$$Y = a_1 + b_1S_1 + b_2S_2 + e_1 \tag{7}$$

where Y = reading comprehension, S_1 = graphophonic processing, and S_2 = syntactic-semantic processing.

The integrated model may now be captured by the following equations:

$$X_1 = a_1 + b_1S_1 + b_2S_2 + e_1 \tag{8}$$

$$X_2 = a_2 + b_1S_1 + b_2S_2 + b_3X_1 + e_2 \tag{9}$$

$$X_3 = a_3 + b_1S_1 + b_2S_2 + b_3X_1 + e_3 \quad (10)$$

$$Y = a_4 + b_1S_1 + b_2S_2 + b_3X_1 + b_4X_2 + b_5X_3 + e_4 \quad (11)$$

Where multiple feedback relations are called for these formal models of reading may become extremely complex. What should not be forgotten, however, is that these equations are merely the formalization of interpretive models — models, moreover, which were derived from inquiries which for the most part were in the qualitative, not quantitative, research tradition. In the case of the examples used in this paper it would be fair to conclude that had the qualitative research not been conducted in order to facilitate formulation of interpretive models, model formalization would not have been possible. As was noted, however, the nature of model formalization promotes the specification of new and alternative hypotheses which may easily necessitate a return to the qualitative research drawing board.

Kaplan (1964:267) makes a valuable distinction between semantical or interpretive models and formal models. The distinction rests on the notion that the equations of the formal model are analogues of the postulates derived from an interpretive model. The metaphor embedded in the notion of "semantic model" may be particularly apt. The semantic or

meaning system of a language can differ from language to language. For example, measurement systems differ from one language to another. Thus, the users of one meaning system, as opposed to another, use the given system to impose structure on the natural world in order to make it possible to talk about their world. By the same token, the formulators of interpretive models make it easier for those on the inside of the modelling tradition in question to understand the phenomena being interpreted.

There is another component of language, however, which some commentators regard as its core; namely, its syntax or grammar. The grammar of a language refers to the rules governing the patterns of language; rules governing how words are put together in clauses and sentences. Behind the infinite variety of sentences spoken by any five year old there is a set of grammatical rules which gives the child the power to make original utterances. In other words, behind the obvious diversity in language and between languages there are common structures or rules which make such diversity possible. The specification of the form of a model is analogous to the search for the common grammatical features of languages. It is a search for structure and structural invariance. Model formalization alone, however, does not determine invariance since it is not a property of a formal model. The search for structural

invariance, however, motivates the researcher. It is a search which minimally calls for model formalization and generalizability.

This is not to say that the basic difficulty with modelling resides with model formalization. Though we have shown in the case of discourse processing that when model formalization comes after the specification of an interpretive model, unanticipated mathematical specification problems can arise, this does not mean that the basic problem of modelling lies in specifying a model's mathematical form. On the contrary, the basic difficulty with any model arises with the specification of the relationships between the concepts (variables) in the interpretive mode of modelling. After all, it is the interpretive model which directly addresses the most fundamental scientific question; namely, "What the devil is going on here?".

REFERENCES

BARTLETT, F.C. (1932). Remembering. Cambridge, England: Cambridge University Press.

BEEBE, M.J. (1984). The integration of psycholinguistic and discourse processing theories of reading comprehension. Paper presented at the twenty-ninth Annual Convention, International Reading Association, Atlanta.

BEEBE, M.J., BULCOCK, J.W., FAGAN, W.T. & MALICKY, G.V. (1984). Recall strategies and reading comprehension. Unpublished manuscript, Faculty of Education, Memorial University of Newfoundland.

BELLACK, A.H. (1978). Competing ideologies in research in teaching. Uppsala, Reports on Education 1. Uppsala, Sweden: Department of Education, University of Uppsala.

BLALOCK, H.M. Jr. (1963). Correlated independent variables: the problem of multicollinearity. Social Forces, 42, 233-237.

BLALOCK, H.M. Jr. (1964). Causal inferences in non-experimental research. Chapel Hill: University of North Carolina Press.

BULCOCK, J.W. & LEE, W.F. (1983). Normalization ridge regression in practice. Sociological Methods and Research, 11, 3, 259-303.

BULCOCK, J.W., LEE, W.F. & LUK, W.S. (1981). The theory of normalization ridge regression. ED 178 581. Washington, D.C.: National Institute of Education, Educational Resources Information Center.

CHRIST, C.F. (1966). Econometric models and methods. New York: John Wiley.

CLYMER, T. & SUMMERS, E.G. (1965). Introducing a new journal. Reading Research Quarterly, 1, 1, 3.

DRUM, P.A. (1978). Prose recall responses and categories for scoring. In P.D. Pearson & J. Hansen (Eds.), Reading: disciplined inquiry in process and practice. Twenty-seventh Yearbook of the National Reading Conference. Clemson, S.C.: The National Reading Conference.

DRUM, P.A. & LANTAFF, R.E. (1977). Scoring categories for protocols. Paper presented at the Second Annual Language Conference, Boston University.

FAIRWEATHER, P. & FARSTRAP, A. (1977/78). The fourth 'R'. Reading Research Quarterly, 13, 1, 3-6.

FARR, R. & WEINTRAUB, S. (1969/70). Editorial. Reading Research Quarterly, 5, 1, 3.

FARR, R. & WEINTRAUB, S. (1976/77). Editorial. Reading Research Quarterly, 13, 2, 171-172.

FARRAR, D.W. & GLAUBER, R.R. (1967). Multicollinearity in regression analysis: the problem revisited. Review of Economics and Statistics, 49, 92-107.

FREDERICKSEN, C.H. (1977). Semantic processing units in understanding text. In R.O. Freedle (Ed.), Discourse production and comprehension (Vol. 1). Norwood, N.J.: Ablex, 1977.

FREDERICKSEN, C.H. (1979). Discourse comprehension and early reading. In L.B. Resnick & P.A. Weaver (Eds.), Theory and practice of early reading (Vol. 1). Hillside, N.J.: Lawrence Erlbaum Associates.

HOERL, A.E., KENNARD, R.W. & BALDWIN, K.F. (1975). Ridge regression: some simulations. Communication in Statistics, 4, 2, 105-123.

KAPLAN, A. (1964). The conduct of inquiry: methodology for behavioral science. San Francisco: Chandler.

KASARDA, J.D. & SHIH, W.F. (1977). Optimal bias in ridge regression approaches to multicollinearity. Sociological Methods and Research, 5, 461-470.

KING, E.M. & HIERONYMUS, A.N. (1974). Canadian tests of basic skills. Toronto ;Thomas Nelson.

KINTSCH, W. (1974). The representation of meaning in memory. Hillsdale, N.J.: Lawrence Erlbaum Associates.

KINTSCH, W. (1976). Memory for prose. In C.N. Cofer (Ed.), The structure of human memory. San Francisco: Freeman.

KINTSCH, W. (1977). Reading comprehension as a function of text structure. In A.S. Reber and D.L. Scarborough (Eds.), Toward a psychology of reading. Hillsdale, N.J.: Lawrence Erlbaum Associates.

KINTSCH, W. & KEENAN, J. (1973). Reading rate and retention as a function of the number of propositions in the base structure of sentences. Cognitive Psychology, 5, 257-274.

KINTSCH, W. & VAN DIJK, T.A. (1978). Toward a model of text comprehension and production. Psychological Review, 85, 363-394.

KINTSCH, W. & VIPOND, D. (1979). Reading comprehension and readability in educational practice and psychological theory. In L. Nilsson (Ed.), Proceedings of the conference on memory, University of Uppsala. Hillsdale, N.J.: Lawrence Erlbaum Associates.

KISH, L. (1975). Representation, randomization and control. In H.M. Blalock Jr. et al. Mathematical models and international perspectives on mathematical sociology. New York: Academic.

LAWLESS, J.F. & WANG, P. (1976). A simulation study of ridge and other regression estimators. Communications in Statistics, A5, 4, 306-323.

MANDLER, J.M. (1979). Categorial and schematic organization in memory. In C.R. Puff (Ed.), Memory organization and structure. New York: Academic Press.

MANDLER, J.M. & JOHNSON, N.S. (1977). Remembrance of things parsed: story structure and recall. Cognitive Psychology, 9, 111-151.

MEYER, B.J.F. (1975). The organization of prose and its effect on recall. Amsterdam: North Holland.

MEYER, B.J.F. (1977). What is remembered from prose: a function of passage structure. In R.O. Freedle (Ed.), Discourse production and comprehension (Vol. 1). Norwood, N.J.: Ablex.

MINSKY, M. (1975). A framework for the representation of knowledge. In P. Winston (Ed.), The psychology of computer vision. New York: McGraw-Hill.

NORMAN, D.A. & RUMMELHART, D.E. (1975). Explorations in cognition. San Francisco: Freeman.

PEARSON, P.D. & SAMUELS, S.J. (1980). Why comprehension? Reading Research Quarterly, 15, 2, 181-182.

SCHANK, R.C. & ABELSON, R.P. (1977). Scripts, plans, goals and understanding. Hillsdale, N.J.: Lawrence Erlbaum Associates.

STEIN, N.L. (1978). How children understand stories: a developmental analysis. Center for the Study of Reading, University of Illinois.

STEIN, N.L. & GLENN, C.G. (1979). An analysis of story comprehension in elementary school children. In R. Freedle (Ed.), New directions in discourse processing. Norwood, N.J.: Ablex.

THORNDYKE, P.W. (1977). Cognitive structures in comprehension and memory of narrative discourse. Cognitive Psychology, 9, 77-110.

TIERNEY, R.J., BRIDGE, C. & CERA, M.J. (1978). The discourse processing operations of children. Reading Research Quarterly, 14, 537-569.

VINOD, H.D. (1978). A survey of ridge regression and related techniques. Review of Economics and Statistics, 60, 121-131.

WEINTRAUB, S. & FARR, R. (1977/78). Editorial. Reading Research Quarterly, 13, 2, 171-172.

WILLER, D. & WEBSTER, M. (1970). Theoretical concepts and observables. American Sociological Review, 35, 4, 748-757.

WOLF, R.L. & TYMITZ, B.L. (1976/77). Ethnography and reading: matching inquiry mode to process. Reading Research Quarterly, 12, 1, 5-11.

VAN DIJK, T.A. (1977). Semantic macro-structures and knowledge frames in discourse comprehension. In M.A. Just & P.A. Carpenter (Eds.), Cognitive Processes in Comprehension. Hillsdale, N.J.: Lawrence Erlbaum.

Table 1

Correlations, Levels of Statistical Significance, Means and Standard Deviations in the Recall Strategies Model of Reading[a]

Variables	X_1	X_2	X_3	X_4	Y	$\bar{X}$	SD
X_1 Text Specific		.0001	.001	.0001	.006	5.54	10.79
X_2 Text Entailed	.714		.004	.0001	.0001	9.65	10.82
X_3 Text Erroneous	.303	.269		.005	.019	3.94	10.16
X_4 Text External	.458	.387	.266		.097	2.69	10.15
Y Reading	.271	.391	-.226	.143		51.16	18.62

[a]Correlation coefficients below the diagonal; the level of statistical significance above the diagonal.

Table 2

Ordinary Least Squares Regression Results

	Dependent Variable Y-Reading				
Independent Variables	Beta Coeff.	Standard-ized beta	Standard Error	Simple r	t value
X_1 Text Specific	.056	.049	.162	.271	.342
X_2 Text Entailed	.418	.437	.132	.391	3.170
X_3 Text Erroneous	-.803	-.372	.220	-.226	3.650
X_4 Text External	.146	.050	.317	.143	.459

Table 3

Comparisons Between an Ordinary Least Squares Estimate and Four Ridge Regression Estimates of the Parameters of the Recall Strategies Model of Reading[a]

Estimating Method	Text Specific Reg Coeff	Text Specific Stand Beta	Text Entailed Reg Coeff	Text Entailed Stand Beta	Text Erroneous Reg Coeff	Text Erroneous Stand Beta	Text External Reg Coeff	Text External Stand Beta	Dmax	k-value	R^2
1. OLS	.056 (.162)	.049	.418 (3.170)	.437	-.803 (3.650)	-.372	.146 (.459)	.050	.570	0	.276
2. Bulcock & Lee, 1983	.095 (.819)	.084	.337 (3.531)	.352	-.684 (3.620)	-.317	.133 (.509)	.046	.092	.132	.208
3. Kasarda & Shih, 1977	.093 (.781)	.082	.343 (3.506)	.358	-.693 (3.625)	-.321	.136 (.504)	.047	.128	.120	.213
4. Hoerl, Kennard & Baldwin, 1975	.090 (.745)	.080	.348 (3.481)	.364	-.701 (3.630)	-.325	.136 (.500)	.047	.165	.108	.218
5. Lawless & Wang, 1976	.094 (.817)	.083	.338 (3.530)	.353	-.684 (3.621)	-.317	.133 (.509)	.046	.093	.131	.208

[a] t-values are presented in parentheses below the regression coefficients. The parameter estimates reported in this table are for an equation where the Y variable is a measure of reading comprehension.